DOCUMENT RESUME

ED 465 467 PS 030 465

AUTHOR Marcon, Rebecca A.
TITLE Rate of Physical Growth and Its Affect on Head Start Children's Motor and Cognitive Development.
PUB DATE 2002-06-00
NOTE 12p.; Paper presented at the Head Start Sixth National Research Conference (6th, Washington, DC, June 26-29, 2002). Supported in part by the Human Growth Foundation Small Grants Program.
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Birth Weight; *Cognitive Development; Developmental Delays; Low Income; *Motor Development; Performance Factors; *Physical Development; *Preschool Children; Preschool Education; Sex Differences
IDENTIFIERS Anthropometric Tests; Project Head Start

ABSTRACT

In the United States, growth retardation is higher among low-income children, with adverse cognitive effects of undernutrition more prevalent when combined with poverty. This study examined anthropometric indicators of physical development and their relationship to motor and cognitive development in Head Start children. Motor integration and sequential and simultaneous memory were examined in relationship to rate of physical growth. The sample of 34 rural Head Start children was 59 percent female; 82 percent of the sample was Caucasian; 18 percent was African American. Twenty-six percent of the sample was classified as low birthweight. Anthropometric data were collected monthly. Motor and cognitive measures were administered 4 times at 10-week intervals. Mean anthropometric changes across the 9-month period were graphed. After controlling for age, analyses indicated significant increases in height, body mass index (BMI), and head circumference across the year. Boys and girls were similar on all anthropometric measures but boys' head circumference was greater. Although low-birthweight children were similar to peers in height, they weighed less, and had lower BMIs and smaller arm circumference. Analyses indicated improvement across the school year in three motor and four cognitive measures: visual motor integration, hopping-right foot, finger control, "magic window," word order, matrix analogies, and spatial memory. No cognitive differences were found between boys and girls, and motor differences were limited to girls' great skill at hopping, skipping, and finger control. Relationships between rate of physical growth and memory and motor development were explored further. (Contains 17 references.) (HTH)

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Rebecca A. Marcon

University of North Florida

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Poster session presented at Head Start's Sixth National Research Conference, Washington, DC, June 26-29, 2002. This research was supported in part by the Human Growth Foundation Small Grants Program, Glen Head, NY. Address correspondence to Rebecca A. Marcon, Department of Psychology, University of North Florida, Jacksonville, FL 32224-2673. Office: (904) 620-2807 Email: rmarcon@unf.edu

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Abstract

In the United States, growth retardation is higher among low-income children, with adverse cognitive effects of undernutrition more prevalent when combined with poverty. The present study examined anthropometric indicators of physical development and their relationship to motor and cognitive development in Head Start children. Unlike previous studies that used global measures of development, research on brain development guided selection of cognitive and motor measures. Between ages 3-5 dominance shifts from the right to left hemisphere, and rapid myelination of the hippocampus and fiber tracts connecting the cerebellum and pre-motor cortex occurs. Therefore, motor integration and sequential and simultaneous memory were examined in relationship to rate of physical growth. The sample of 34 rural Head Start children (M = 49.03 months) was 59% female, 82% Caucasian, and 18% African American, with 26% classified as low-birth-weight (LBW, < 5.5 lb). Anthropometric data (height, weight, body mass index-BMI, mid-arm and head circumference) were collected monthly. Motor and cognitive measures were administered four times at 10 week intervals. Mean anthropometric changes across the 9-month period were graphed. After controlling for age, analyses indicated significant increases in height, BMI, and head circumference across the year. Boys and girls were similar on all anthropometric measures except boys' head circumference was greater. Although LBW children were similar to peers in height, they weighed less, had lower BMIs, and smaller arm circumference. Analyses indicated improvement across the school year in three motor and four cognitive measures: Visual Motor Integration, Hopping-right foot, Finger Control, Magic Window, Word Order, Matrix Analogies, and Spatial Memory. No cognitive differences were found between boys and girls, and motor differences were limited to girls' greater skill at hopping, skipping, and finger control. Relationships between rate of physical growth and memory and motor development were explored further.

Rate of Physical Growth and Its Affect on Head Start Children's

Motor and Cognitive Development

Anthropometric measures have been used in research linking growth retardation with cognitive development in postnatally undernourished children. Although children's physical size is affected by many factors other than nutrition, both stunting and wasting have been associated with lower cognitive performance. As an indicator of long-term nutritional status, height for age shows the strongest anthropometric relationship with young children's cognitive development (e.g., Brockman & Ricciuti, 1971; Eisenberg, Roth, Bryniarski, & Murray, 1984, Karp, Martin, Sewell, Manni, & Heller, 1992). Weight for height has been associated with cognitive performance and attention in older children (e.g., Paine, Dorea, Pasquali, & Monterior, 1992). Head circumference and mid-arm circumference also have been related to children's neurodevelopment (e.g., Ivanovic, 1996; Johnson, 1991; Lynn, 1989; Stoch, Smythe, Moodie, & Bradshaw, 1982). In the United States, the prevalence of growth retardation is especially high among low-income children. Adverse effects of undernutrition on cognitive development are more prevalent when combined with poverty (e.g., Karp et al., 1984; Pollitt, Gorman, Engle, Matorell, & Rivera, 1993). Few studies, however, have been conducted in the United States where undernutrition among children is mild-to-moderate and rarely reaches the severe levels of deprivation examined in earlier studies of children in developing nations (Pollitt, 1987).

The present study examined anthropometric indicators of physical development and their relationship to motor and cognitive development in at-risk, low-income U.S. children enrolled in Head Start. Unlike previous studies that used more global measures of development, findings from research on brain development guided selection of cognitive and motor measures used in this study. Between the ages of 3-5 there is a shift from right to left

hemisphere dominance, as well as rapid myelination of the hippocampus and fiber tracts connecting the cerebellum and pre-motor cortex (e.g., Case, 1992; Fischer & Rose, 1997; Thatcher, 1994). Therefore, motor integration and performance on measures of sequential and simultaneous memory were examined in relationship to rate of these preschoolers' physical growth.

Method

Sample

Parents of all 34 children (ages 3-5, *M* at beginning of study = 49.03 mos, *SD* = 7.28) enrolled all 9 months in a full-day, rural Head Start center gave written informed consent for children's participation in this study. The sample was 59% female, 82% Caucasian and 18% African American. All children lived in households with an annual income at or below federal poverty guidelines. Birth weights ranged from 2 lb-2oz to 10 lb-1oz (*M* = 6.50 lb, *SD* = 1.48 lb), with 26% of the sample classified as low-birth-weight (< 5.5 lb).

Measures

Data were collected mornings at the Head Start center by a team of six researchers beginning the fourth week of the school year. Anthropometric data were collected monthly and motor and cognitive measures were administered four times at approximately 10 week intervals. Weight was measured prior to breakfast and all cognitive and motor measures were made following breakfast to control for energy levels. Standard anthropometric procedures were used to collect data on children's standing height (cm), weight (kg), mid-arm (cm) and head circumference (cm). Body mass index (BMI) was calculated for each child using the Center for Disease Control (CDC) formula: (wt ÷ ht) ÷ ht. Gross and fine motor development were assessed using six items from a preschool screening tool (Developmental Indicators for the Assessment of Learning-Revised, DIAL-R; Mardell-Czudnowski & Goldenberg, 1990):

catching, hopping, skipping, block building, finger control, cutting. Both visual and auditory memory were assessed using age-appropriate subtests of the Kaufman Assessment Battery for Children (K-ABC; Kaufman & Kaufman, 1983). Development of the pre-motor cortex was assessed by the Berry-Buktenica Developmental Test of Visual Motor Integration (VMI; Berry & Buktenica, 1997) which compared children's copying of 18 geometric designs with age-based norms. Teachers rated children's daily food intake (breakfast, lunch, afternoon snack) from weeks 3 through 6 using a 4-point comparative scale: 0 = absent, 1 = ate less than other children, 2 = ate same amount as other children, 3 = ate more than other children.

Results

Based on June 2000, statistics from the Center for Disease Control, 2 of 34 children in this sample were classified as stunted (ht < 5th percentile for age and sex) at the beginning of the school year. Although both of these children increased in height across the school year, they remained stunted in height at the end of the year. One of these children was classified as wasted (wt < 5th percentile for age and sex) at the beginning of the school year. Weight gains placed this child just outside the wasted classification at the end of the school year (increased from 1.7th percentile to 5.9th percentile).

Mean changes in anthropometric measures across the 9- month period of children's enrollment in Head Start were graphed (see Figures 1- 4). After controlling for age, repeated

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Insert Figures 1, 2, 3 and 4 about here

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measures MANCOVA (with Huynh-Feldt correction as needed) indicated significant increases in height, $F(3.3, 89.4) = 9.29$, $p = .000$, BMI, $F(5.1, 138) = 2.64$, $p = .02$, and head circumference, $F(3.6, 79.5) = 3.32$, $p = .02$, across the school year. Further analyses indicated boys and

girls were similar on all anthropometric measures except boys' head circumference was approximately 1.6 cm greater than girls', $F(1, 27) = 9.29$, $p = .005$. Although low-birth-weight (LBW) children were similar to peers in height (LBW = 103.3 cm, non-LBW = 104.9 cm; $p = .28$), they weighed an average of 2.2 kg less, $F(1, 27) = 3.78$, $p = .06$, with lower BMI scores (LBW = 15.21, non-LBW = 16.60), $F(1, 26) = 3.16$, $p = .08$. Mean mid-arm circumference of LBW children was 1.4 cm smaller than that of non-LBW classmates, $F(1, 27) = 4.24$, $p = .05$.

After controlling for age, repeated measures MANCOVA (with Huynh-Feldt correction as needed) indicated significant improvement across the school year in three motor and four cognitive measures. Motor gains were seen in (a) VMI scores, $F(3, 24) = 5.14$, $p = .007$, (b) Hopping-right foot, $F(3, 23) = 3.34$, $p = .04$, and (c) Finger Control, $F(2.8, 71.2) = 2.44$, $p = .07$. Cognitive gains were seen in (a) Magic Window (simultaneous, visual-vocal), $F(1.4, 35.6) = 3.12$, $p = .07$; (b) Word Order (sequential, auditory-motor), $F(1.3, 25.3) = 17.70$, $p = .000$; (c) Matrix Analogies (simultaneous, visual-motor), $F(2, 4) = 20.00$, $p = .008$; and (d) Spatial Memory (simultaneous, visual-motor), $F(2, 5) = 4.54$, $p = .075$. [Note. Degrees of freedom varied because different K-ABC tests were administered at different ages.] No significant cognitive differences were found between boys and girls, and motor differences were limited to girls' greater skill at hopping (right foot, F (1, 25) = 7.03, $p = .01$; left foot, $F(1, 25) = 7.50$, $p = .01$), skipping, $F(1, 23) = 5.04$, $p = .04$, and finger control, $F(1, 25) = 4.42$, $p = .05$. Although LBW children scored lower on 5 of 7 cognitive measures compared to non-LBW classmates, these differences were not statistically significant. Gross motor skills of LBW children were comparable to or slightly better than those of non-LBW peers, but their fine motor skills were somewhat lower than non-LBW peers and they scored significantly lower on scissors cutting, $F(1, 25) = 8.42$, $p = .008$.

Rate of physical growth was examined for the two anthropometric measures that showed

the most change across the school year, height and weight. The proportion of overall increase in height and weight that occurred between each period of motor and cognitive assessment was calculated. Children were then categorized according to the period in which they had experienced the most change: early in the year, middle of the year, late in the school year. There were no significant differences between the height or weight groups at baseline measurement of motor and cognitive development. By mid-year, gross motor skills were notably better among children who had experienced their greatest period of growth early in the school year. By the end-of-the-year, these same children were performing better on cognitive measures (number recall and matrix analogies) than children whose height increases came later in the year. Children whose greatest weight gains were in the middle of the year did poorer than peers on several mid-year cognitive measures (magic window and hand movements). Although period of greatest height or weight increases were not associated with age or birth status, girls were more likely to experience their greatest height increase early in the year while boys were more likely to increase most in height at the end of the year, χ^2 (2, N = 32) = 5.62, p = .06.

Implications

These findings add to our understanding of the relationship between physical growth and motor and cognitive development and expand the small data base in this area of study by demonstrating outcomes for children from industrialized nations. Even within an at-risk, low-income population of preschoolers, anthropometric variability exists, and these differences are related to development of memory processing capacities (both auditory and visual), motor skills, and sensory-motor integration.

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Figure 1

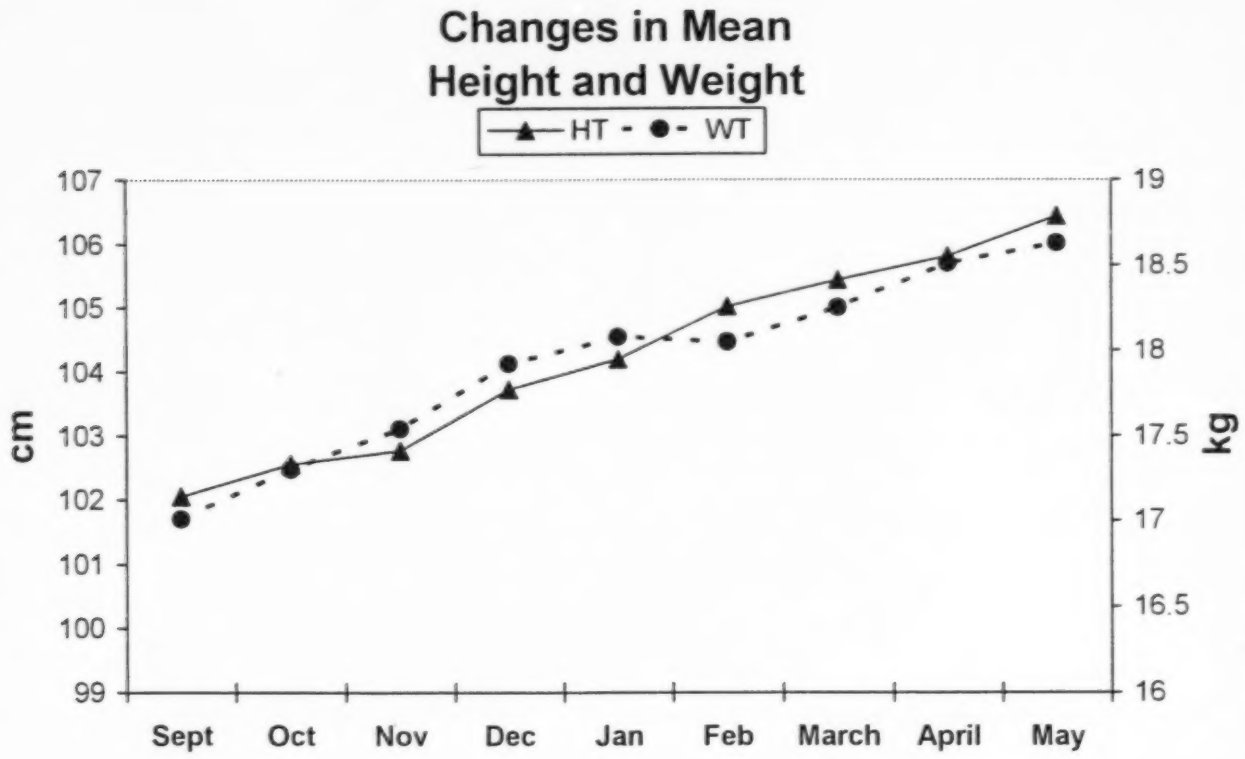

Figure 2

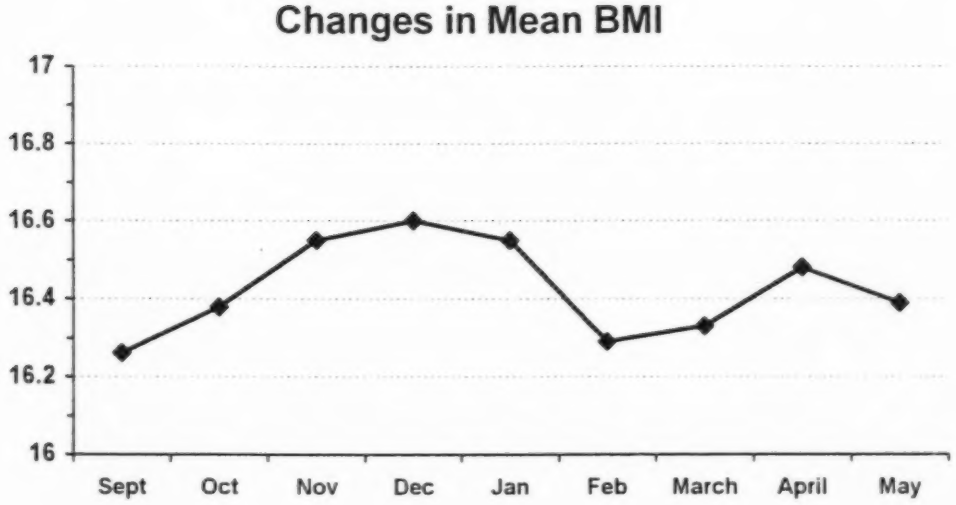

Figure 3

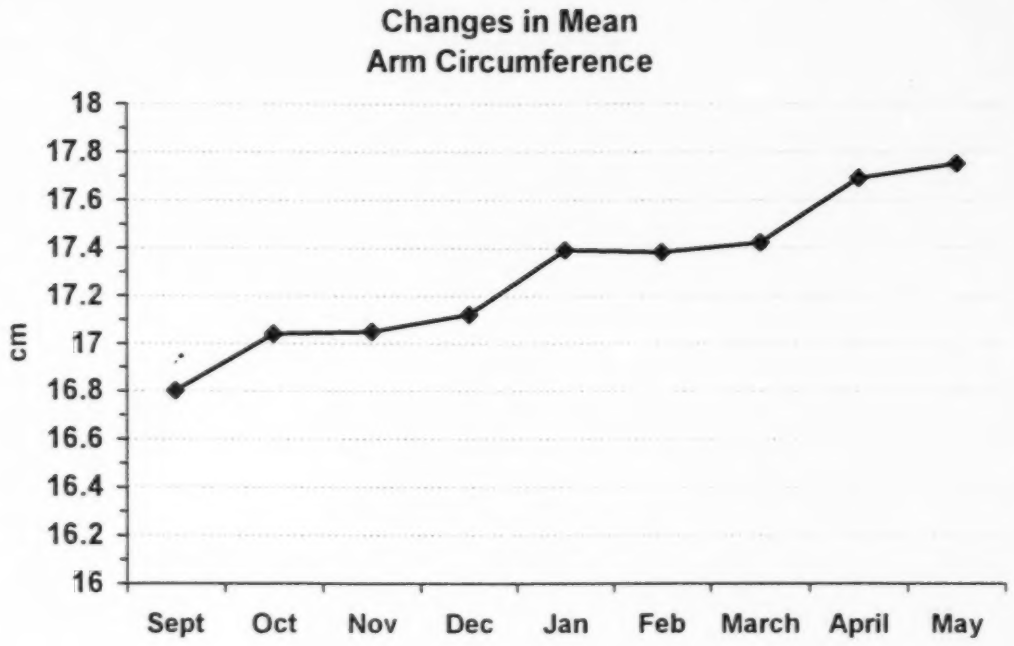

Figure 4